



function of detecting the occurrence of a bell signal on the line to enable the user equipment to pick up to receive a call, for example a fax in the case of a modem. Bell detection circuit 4 is connected to modem 2, on the user equipment side, via an isolation circuit 7 formed, in the example of Fig. 1, of an optocoupler. Optocoupler 7 is generally formed of a light-emitting diode 8, the two terminals of which are connected to two output terminals of circuit 4 and of an opto-transistor 9, the emitter and the collector of which are connected to modem 2.

On the side of user equipment 2, the secondary winding 3s of the transformer is generally connected to a so-called hybrid two wire – four wire circuit (not shown) intended for enabling the sending and receiving of a wanted signal over a same transmission line and for separating the transmitted signals from the received signals.

A disadvantage of conventional interface circuits, which translates as a functional disadvantage of modems, is that they are not able to detect the state of telephone line 1, that is, to know whether this line is busy or not. This disadvantage is particularly disturbing in the case where a same telephone line is shared between a conventional telephone equipment and a modem. In such a case, the computer exploiting the modem is incapable of knowing whether a conversation is on the line when it desires to transmit by means of the modem. Conventionally, the modem tries to perform a connection on the line, and its processing program generates an error message for the user (visible on the computer screen) to indicate that the connection has failed. This detection cannot be performed without the modem trying to take up the line. Accordingly, this results, for the user of a telephone set or for another modem occupying the line, in a pollution of the signal (audible or data pollution).

#### SUMMARY OF THE INVENTION

The embodiments of the present invention aim at overcoming the disadvantages of conventional interface circuits by enabling detection of the line state by the modem.

The embodiments of the present invention also aim at respecting the isolation constraints between the transmission line and the user equipment.

The embodiments of the present invention also aim at enabling a detection of the line state without it being necessary to operate a line take-up circuit generally  
5 provided in the interface circuit.

The disclosed embodiments of the present invention further aim at providing a solution that optimizes the number of components necessary to cross the isolation barrier.

To achieve the foregoing, the embodiments of the present invention provide an interface circuit including means forming a galvanic isolation barrier between a  
10 transmission line and a user equipment, and means for detecting, independently from a transmission, the idle or busy state of the line.

According to an embodiment of the present invention, said detection means include, on the line side with respect to the isolation barrier, an oscillating circuit associated with an element detecting that a voltage threshold has been exceeded, only  
15 supplying the oscillating circuit when the line state is not busy, and on the user equipment side, a circuit for detecting the amplitude of an oscillating signal provided by said oscillating circuit and having transited through the isolating means.

According to an embodiment of the present invention, the interface circuit includes a detector of the presence of a bell signal on the line, translating as a ripple of high  
20 amplitude thereon.

According to an embodiment of the present invention, the bell signal detector and said means for detecting the idle or busy state of the line share the same galvanic isolation means.

According to an embodiment of the present invention, the bell signal  
25 detector detects the exceeding of a voltage threshold on the line.

According to an embodiment of the present invention, the interface circuit includes means for modulating the supply amplitude of the oscillating circuit according to whether a bell signal is present or not on the line.

According to an embodiment of the present invention, the interface circuit includes, on the equipment side, an output stage providing two logic signals for the user equipment, said signals providing, in combination, three states respectively corresponding to an idle state of the line, to a busy state of the line, or to the presence of a bell signal  
 5 thereon.

According to an embodiment of the present invention, the interface circuit includes a means for rectifying the signal present on the line.

The foregoing features and advantages of the present invention will be discussed in detail in the following non-limiting description of specific embodiments in  
 10 connection with the accompanying drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1, previously described, is intended for showing the state of the art and the problem to solve;

Fig. 2 partially shows, in a simplified manner, an embodiment of an  
 15 interface circuit according to the present invention;

Fig. 3 shows a simplified example of embodiment of a bell detection circuit;

Fig. 4 shows a second preferred embodiment of an interface circuit according to the present invention;

Figs. 5A to 5H illustrate, in the form of timing diagrams, the operation of an  
 20 interface circuit according to the preferred embodiment of the present invention; and

Fig. 6 is a detailed electric diagram of the line state and bell detection circuit shown in Fig. 4.

#### DETAILED DESCRIPTION OF THE INVENTION

The same elements have been designated by the same references in the  
 25 different drawings. For clarity, the timing diagrams of Figs. 5A to 5H have been drawn out of scale and only those elements of the interface circuit which are necessary to the understanding of the present invention have been shown in the drawings and will be

described hereafter. In particular, different control and detection circuits (for example, the line take-up circuit) have not been shown in the drawings and are no object of the present invention. Similarly, the hybrid circuits generally associated with the interface circuit are no object of the present invention and have not been shown in the drawings.

5           A feature of the present invention is to provide, on the transmission line side, that is, opposite to the isolation barrier with respect to the user equipment, an oscillating circuit adapted to providing an oscillating signal at least when the transmission line is idle.

10           The present invention takes advantage of the differences between the levels of the voltages present on the transmission line according to its different states. Indeed, in the idle state, that is, when the line is free, the voltage present between the two conductors T and R (Fig. 1) is set by the telephone operator to a first level (for example, 48 volts). This D.C. voltage level may be positive or negative, that is, the telephone operator does not set the biasing of the line when idle. The occurrence of a bell signal on the line results in  
 15           the presence of a sinusoidal signal of very high amplitude as compared to the idle voltage. For example, this sinusoidal voltage has an amplitude on the order of 200 peak volts. When the transmission line is busy, that is, when a voice or data communication transits thereon, the current consumption results in a drop of the line voltage generally amounting to more than half its idle voltage. Thus, referring to the example of an idle line at a 48-volt  
 20           potential, when the line is busy, its mean level is lower than 20 volts.

25           Considering this, the embodiments of the present invention generate an oscillating signal when the line is idle and sending this oscillating signal through the isolation barrier of the interface circuit to the user equipment. It being an oscillating signal, it may transit, for example, through a capacitor, which is a preferred embodiment of the present invention, due to its low cost as compared to a transformer.

Fig. 2 partially shows in a simplified manner a first embodiment of the present invention.

As previously, a telephone line 1 symbolized by its two conductors T and R is connected, for the transmission of information and data to a user equipment (for

example, a modem 2), to primary 3p of an isolation transformer 3, the secondary 3s of which is connected to modem 2.

According to the first embodiment illustrated in Fig. 2, the circuit includes, like a conventional interface circuit, a bell detection circuit (SONN) 4, two input terminals 5 and 6 of which are connected to conductors T and R, and the detection outputs of which are connected to modem 2 via a galvanic isolation means 7 (for example, an optocoupler OPTO).

According to the present invention, a line state detection circuit 10 is provided with, on the side of line 1, an oscillating circuit (OSC) 11, and on the side of user equipment 2, a voltage level detector 12 (DET). The detector is, preferably, a peak amplitude detector.

On the line side, oscillating circuit 11 is associated, at its input, with a voltage measurement element of the type detecting the exceeding of a voltage threshold, the function of which is to only supply oscillating circuit 11 when the voltage across the line exceeds a threshold V13. In the example of Fig. 2, the voltage threshold detection circuit is formed of a zener diode 13, the anode of which is connected to a supply terminal 14 of oscillating circuit 11 and the cathode of which is intended for receiving the signal present on the transmission line.

Since the biasing of the transmission line is not set by the operator, a rectifying means 15, for example a diode bridge, is provided between the conductors of line 1 and the line state detection circuit of the present invention. The rectifying performed by circuit 15 is fullwave to enable a detection independently from the line biasing. A positive output 16 of rectifying element 15 is connected to the cathode of zener diode 13 while reference output 17 of the rectifying element is connected to a second input terminal 18 of oscillating circuit 11. Terminal 18 forms the reference terminal of this oscillating circuit. At its output 19, circuit 11 provides an oscillating signal only when the level of the voltage between terminals 16 and 17 exceeds voltage V13 set by element 13. This oscillating signal then transits through isolation barrier IB. The galvanic isolation is, in the

embodiment illustrated in Fig. 2, obtained by means of two capacitors 20, 21, respectively receiving the signals present on terminals 19 and 17.

On the side of user equipment 2, capacitor 20 is connected to an input terminal 22 of voltage level detector 12, output 23 of which provides the result of the detection to modem 2. The reference level of the detection signal is set by the second electrode 24 of capacitor 21, which is connected to modem 2.

Zener diode 13 is sized so that, when the voltage level between terminals 16 and 17 is smaller than the voltage level corresponding to the idle state of the line, the oscillating circuit is not supplied. Thus, oscillating circuit 11 is supplied and provides a signal on capacitor 20, be it when the line is idle or in the presence of a bell signal having a peak or mean level greater than the voltage level in the idle state.

Optionally, a protection component 25 may be provided across input terminals 14 and 18 of oscillating circuit 11. Component 25 illustrated in dotted lines in Fig. 2 may be formed of a zener diode, the anode of which is connected to terminal 18 and the cathode of which is connected to terminal 14. Its function can then be to limit the input voltage of the oscillating circuit in the presence of a bell signal of several hundreds of volts.

It should be noted that, with a detector 12 only detecting the presence of an oscillating signal on capacitor 20, the result at output 23 of detector 12 makes no difference between the idle state of the line and the presence of a bell signal. However, since a bell detector 4 is provided in parallel, modem 2 is, in this embodiment, capable of interpreting the results from the two detectors by logic means to dissociate the two states.

As an alternative, an improved amplitude detector 12 may be provided, which only provides a positive detection result when the voltage level of the oscillating circuit crossing capacitor 20 is included between two values, that is, greater than a threshold representative of the idle state of the line and smaller than a threshold representative of the presence of a bell signal.

Fig. 3 shows an example of a bell detection circuit 4 likely to be used in the embodiment of Fig. 2. The two input terminals 5 and 6 of detector 4 are respectively sent

onto a first electrode of a capacitor 30 and onto the emitter of an output transistor 31. The second electrode of capacitor 30 is connected to the cathode of a zener diode 32, the anode of which is connected to the base of transistor 31. Collector 33 of transistor 31 forms the other output terminal of bell detector 4. The presence of capacitor 30 enables avoiding that the D.C. level of the line in the idle state biases transistor 31, only the A.C. bell signal transiting through this transistor 30. Zener diode 32 is chosen so that its threshold is greater than the possible ripple with respect to the D.C. level, be it due to the oscillations of the transmitted information when the line is busy or to noise when the line is idle.

It should be noted that other conventional bell detection circuits may be used instead of the example illustrated in Fig. 3.

An advantage of the present invention is that modem 2 can detect whether line 1 is idle or busy without having to take it up. Accordingly, this detection generates no pollution on the line.

Fig. 4 shows a second preferred embodiment of a circuit 40 for detecting the state of a transmission line. The embodiment of Fig. 4 especially aims at minimizing the number of components necessary to have the signals transit through isolation barrier IB (Figs. 1 and 2).

On the data transmission side (transformer 3), this embodiment is not different from the embodiment of Fig. 2. Further, detection circuit 40 uses an oscillating circuit 11, a detector of the exceeding of a voltage threshold 13, and a fullwave rectifying means 15 on the line side with respect to the isolation barrier, as in the embodiment of Fig. 2. Downstream of the isolation barrier, this detector uses an amplitude detector 12 again and isolation barrier IB is crossed, as in the embodiment of Fig. 2, by means of two capacitors 20 and 21.

A feature of the preferred embodiment of the present invention is to combine the bell and line state detection within a same detector. According to this embodiment, the isolation barrier is crossed by two connections only instead of four in the first embodiment. For this purpose, the present invention takes advantage of the fact that





then aims at short-circuiting diode 46 in the absence of a bell signal. This switch is a normally-on switch.

When the line is busy, that is, when its voltage level is lower than the idle voltage level (commonly called the battery level), zener diode 13 blocks the supply of  
5 oscillating circuit 11.

When the line is idle and in the absence of a bell signal, circuit 11 is powered and its supply voltage is limited by diode 42. Accordingly, the oscillating signal at the output of circuit 11 has a first relatively low amplitude.

In the presence of a bell signal, detector 44 turns off switch 43, which  
10 results in placing zener diodes 42 and 46 in series. The supply amplitude of oscillating circuit 11 is then higher than when the line is idle, which results, at the output of circuit 12, in a higher amplitude.

Isolation barrier IB is crossed by the signals provided by the oscillating circuit as in the first embodiment. Level detector 12 receives these signals and provide, on  
15 its output terminal 23, a relatively high voltage level in the presence of a bell signal and a relatively low level in the absence of a bell signal. It should be noted that, as previously, this voltage level is null in the case where the line is busy. Terminal 23 is connected to a first switch 47 (for example, a bipolar transistor) of output stage 41. The collector of transistor 47 is connected to a terminal 48 of application of a positive biasing voltage  $V_{cc}$   
20 (for example, 5 volts, to correspond to a logic level) via a resistor R1. The emitter of transistor 47 is connected to ground 24. A first logic output 49 is sampled from the collector of transistor 47 for modem 2. This output is high when switch 47 is off and low when said switch is on, that is, in the presence of an idle line or of a bell signal.

According to the preferred embodiment of the present invention, terminal 23  
25 is also connected to the control terminal of a second switch 50 via a zener diode 51 (or an equivalent voltage threshold detector). Switch 50, formed for example in the form of a bipolar transistor, has its collector connected to terminal 48 via a biasing resistor R2 and its emitter connected to ground 24. The threshold of zener diode 51 is chosen to be included between the two relatively high and relatively low levels provided by detector 12. The



5D) in an oscillating signal at a relatively low level V11 at the oscillating circuit output. This results in an amplitude V42 of the oscillations at the output of circuit 11 corresponding to the threshold voltage of diode 42. At the input of circuit 12 (Fig. 5E), these oscillations are, after crossing the isolation barrier, centered back on the equipment ground. At the output of detection circuit 12 (Fig. 5F), the voltage level is lower than threshold voltage V51 of zener diode 51. Accordingly, switch 50 is off while switch 47 is on. Level V49 is thus low while level V52 is at logic state 1 (substantially corresponding to supply voltage Vcc).

It is assumed that a bell signal appears at a time t1. This bell signal results in an oscillation of the line voltage with a peak amplitude of several hundreds of volts around level Vbat. Whether the line is positively or negatively biased, the rectification performed by circuit 16 enables obtaining the same waveform whatever the biasing (see the timing diagram of Fig. 5C). The amplitude of signal V15 at the bridge output is greater than threshold V13 of diode 13. Further, bell detector 44 turns off switch 43, which results in placing diode 46 in series with diode 42. Accordingly, the supply amplitude of circuit 11 corresponds to the sum of thresholds V42 and V46 of diodes 42 and 46. This results in an increase of the amplitude of oscillating signal V11, and thus of voltage level V12S at the output of detector 12. The sizing of zener diode 51 is chosen so that its threshold voltage V51 is then smaller than the level of voltage V12S. Accordingly, both switches 47 and 50 are on and signals V49 and V52 are both at the low logic level.

It is assumed that at a time t2, the bell signal disappears and the line remains idle. This is the same situation as previously described before time t1.

Assuming that at a time t3, the line becomes busy, be it for modem 2 itself or for another equipment connected on the line, this busy state results in a drop of line voltage V1 to a mean level Vm lower than battery level Vbat (Fig. 5A) or -Vbat (Fig. 5B). This level decrease is reflected on the output V15 of the rectifying bridge. Output voltage V15 is then smaller than threshold voltage V13 of the input zener diode of the oscillating circuit. Accordingly, said circuit is no longer powered and provides no output signal. This results in no powering of detection circuit 12, the output signal of which can thus not be

greater than threshold voltage V51 of diode 51. Accordingly, both switches 47 and 50 are off and outputs 49 and 52 are both high.

The modem thus just has to interpret the logic signals present on terminals 49 and 52 to determine the line state with certainty. As an alternative, it may be provided for the modem to directly interpret output signal V12S of circuit 12 and to itself perform an analysis of the voltage levels.

It should be noted that the line occupation may occur just after the presence of the bell signal (for example, after “picking up” by modem 2), and the state described subsequently to time t3 then is found as soon as time t2.

It should also be noted that in Figs. 5F and the following, switching times t1', t2', t3' have been slightly shifted with respect to times t1, t2, and t3 to take account of the times of establishment of the voltage level by detector 12. Indeed, an amplitude detector generally uses a storage element of capacitor type and said capacitor then requires time to charge or discharge when the level switches.

Fig. 6 shows an example of a detailed electric diagram of circuit 40 of the present invention described in relation with Fig. 4. Fig. 6 aims at presenting practical examples of an embodiment of rectifying bridge 15, of oscillating circuit 11, of level detector 12, and of output stage 41, as well as a preferred embodiment of a bell detector 44 associated with a specific embodiment of switch 43.

The preferred embodiment of the bell detector of the present invention has the feature of no longer detecting the presence of an oscillating circuit, as is the case for a conventional detector as well as in the example of Fig. 3, but of only detecting a voltage level. This feature is made possible by the fact that the present invention provides restoring an oscillating signal at the bell detection output. Indeed, in conventional interface circuits, the oscillation must be maintained to cross the isolation barrier. This is no longer necessary by combining the bell detector with the line state detector of the present invention.

Thus, in the embodiment illustrated in Fig. 6, detector 44 is formed of two rectifying diodes 60 and 61 respectively interposed on conductors T and R at the input of

detector 44. The outputs of diodes 60 and 61 are interconnected and thus provide a rectified line voltage. This rectified signal is sent onto the cathode of a zener diode 62, the anode of which is connected to control terminal 64 of switch 43. The function of zener diode 62 is to detect a relatively high voltage level, greater than the battery voltage level  
 5 (idle line). For example, a zener diode 62 or an association of several zener diodes in series forming a threshold on the order of 60 may be provided.

Control terminal 64 of switch 43 corresponds, in this example, to the base of a first NPN-type bipolar transistor 65, the emitter of which is connected to reference line 17 corresponding to one of the rectified outputs of bridge 15. The collector of transistor 65 is  
 10 connected to the base of a second NPN-type transistor 66, the emitter of which is also grounded and the collector of which forms terminal 45 connected to the anode of zener diode 42. A current-limiting resistor R3 is connected between the collector of transistor 66 and that of transistor 65.

An advantage of the embodiment of detector 44 illustrated in Fig. 6 is that,  
 15 except for diodes 60 and 61 which are high-voltage components, the rest of these components are perfectly integrable. By comparison, in an oscillating signal detector, the high-voltage capacitor that is necessary to be provided (30, Fig. 3) is not integrable.

In the example of Fig. 6, fullwave rectifying bridge 15 is formed of four zener diodes 67, 68, 69, and 70. The use of zener diodes rather than simple diodes has the  
 20 advantage of protecting circuit 40. A first A.C. input terminal 71 of bridge 15 is connected to conductor T via a current-limiting resistor R4. A second A.C. input terminal 72 of bridge 15 is connected to conductor R via a current-limiting resistor R5. As will appear from the discussion of the other components of circuit 40, resistors R4 and R5 form, with diodes 60 and 61, the two sole non-integrable components of the circuit of the present  
 25 invention (except for galvanic isolation capacitors 20 and 21).

The anodes of diodes 67 and 68 form together the positive rectified output terminal 16 of bridge 15 connected to the anode of zener diode 13.

Oscillating circuit 11 is based on the use of an NPN-type bipolar transistor 73. The collector of transistor 73 forms terminal 19 of oscillating circuit 11 and is

connected, via a resistor R6, to input terminal 14. The emitter of transistor 73 is connected to reference line 17. The collector and the base of transistor 73 are connected together by means of a biasing resistor R7. The collector of transistor 73 is also connected to its base by a phase-shifting circuit formed of a series association of three capacitors C1, C2, and C3 preferably of same value. The junction point of capacitors C1 and C2 is connected to the base of transistor 73 via a resistor R8, and the junction point of capacitors C2 and C3 is connected to this base via a resistor R9. The three RC components introduce the successive 60-degree phase shifts causing the required oscillation (the three components form a phase-shifter by 180°).

Peak amplitude detection circuit 12 is based on the use of a storage capacitor 74, a first electrode of which is connected to ground 24 and a second electrode of which is connected, via a rectifying diode 75, to capacitor 20, the anode of diode 75 being connected to capacitor 20 that is charged during positive halfwaves of the oscillating circuit. A diode 76 is also provided between capacitors 20 and 21, that is, between the anode of diode 75 and ground 24. The function of diode 76 is to ensure the conduction of the isolating circuit (C20 and C21) during negative halfwaves. It should be noted that diode 75 prevents capacitor 74 from discharging somewhere else than into output stage 41.

Output 23 of detector 12 is sent, via resistors R10 and R11, respectively onto the bases of two transistors 77 and 78 forming NPN-type input transistors of Darlington-type assemblies forming switches 47 and 50. On the side of switch 50, a diode 79 may be provided between zener diode 51 and resistor R11, to lower the capacitance of zener diode 51. The collectors of transistors 77 and 78 form the respective output terminals 49 and 52 of stage 41. These collectors are each connected to the collector of a second NPN-type transistor, respectively 80 and 81, of the corresponding Darlington assembly. The base of transistor 80 is connected to the emitter of transistor 77. The base of transistor 81 is connected to the emitter of transistor 78.

The operation of the detailed diagram of Fig. 6 can be deduced from the operation discussed in relation with Fig. 4. It should be noted that the respective sizings of

